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Tanya Klassen
Pacific University

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GENDER DIFFERENCES IN THE DIETARY INTAKE OF ANTIOXIDANTS IN YOUNG ADULTS

By

TANYA KLASSEN

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Advisors:

Diane Yolton, PhD OD
Karl Citek, OD PhD

Tanya Klassen

Tanya Klassen

Diane P. Yolton

Diane Yolton, PhD OD

Karl Citek

Karl Citek, OD PhD

Biography

Tanya Klassen grew up in Calgary, Alberta. She attended the University of Waterloo in Waterloo, Ontario and graduated with a Bachelor of Science degree in 1994. She is a candidate for the Doctor of Optometry degree from Pacific University in May, 2000. Upon graduation, Tanya plans to return to Calgary to join a private optometric practice.

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Gender Differences in the Dietary Intake of Antioxidants in Young Adults

Tanya Klassen, BSc, Pacific University College of Optometry, Forest Grove, OR, 97116

Abstract

Antioxidants which can only be obtained from the diet are protective against free radical damage which is associated with diseases such as cancer, macular degeneration, and cataracts. A diet high in antioxidants found in fruits and vegetables including spinach is beneficial for general health and ocular health. The daily dietary intake of the antioxidants lutein, beta-carotene, zinc, vitamin C, and vitamin E as well as vitamin A, fat, and iron was determined using a food frequency questionnaire in 49 healthy young adults. Significant gender differences were found for the dietary intake of vitamin C, vitamin E, iron, and zinc with men consuming more than women of these nutrients ($p<0.05$). When adjusted for caloric intake, women consume more lutein than men ($p<0.05$). Males exceeded the Recommended Dietary Allowances (RDA) for all items with RDAs. Females exceeded the RDA for all items except zinc.

Key Words

Carotenoids, macular pigment, age-related macular degeneration, dietary patterns, nutrition, vitamins, minerals, antioxidants

Introduction

Age-related macular degeneration (ARMD) is the leading cause of blindness in people over the age of 65 in Western countries.[1] This retinal disease is thought to be associated with free radical damage. Two carotenoids, lutein and zeaxanthin, are concentrated in the macular area of the retina where they act as antioxidants which can decrease the number of free radicals and thus prevent free radical damage. These carotenoids are also yellow pigment and thus can prevent the formation of free radicals by filtering out blue light before the light reaches the photoreceptors and retinal pigment epithelium.[2]

Gender-specific differences in normal visual structures may account for gender differences in susceptibility to ocular disease. Previous research has found that females have a lower macular pigment density of lutein and zeaxanthin than males.[3] This may place them at greater risk for retinal damage from short wavelength light. Additional evidence of gender-specific differences is suggested by older females having a significantly higher incidence of ARMD compared to males, even after controlling for differences in age.[4]

Lutein and zeaxanthin are among the more than 60 different carotenoids that have been identified in vegetable products that humans consume. The number of carotenoids present in human serum and tissues is more limited. Carotenoids are absorbed by the mucosa of the small intestine, mainly in the duodenum, in conjunction with fat digestion and absorption.[5] In addition to their role in vision, carotenoids may be valuable in reducing the risk of heart disease and cancer.[1]

Lutein and zeaxanthin are oxygenated carotenoids which are found in all fruits and vegetables and provide the yellow color to corn kernels. They are found in highest concentration in dark green leafy vegetables and are also present in xanthophyll concentrates prepared from marigolds.[5] These two compounds are specifically deposited in the macular region of the retina at a high concentration.[6] They are closely related carotenoids and it has been proposed that lutein is converted to zeaxanthin in the retina.[1] They are the compounds responsible for the presence of the macula lutea, or yellow spot, found in the foveal region. Lutein and zeaxanthin are the only carotenoids found in the tissues of the eye, and they are present in virtually all of the different tissues in the eye.[6]

The lutein in the retina is not made by the body but is obtained from the diet. Macular pigment density can be correlated with dietary intake of the carotenoids lutein and zeaxanthin.[3] Lutein is a fat soluble carotenoid, which must be consumed with a fat source in order to be effectively absorbed into the blood stream and subsequently deposited in the macula. Fat intake, therefore, may be a limiting factor for lutein absorption leading to a high macular pigment density. Iron may also enhance absorption of lutein into the blood stream.[3]

Beta-carotene is a hydrocarbon carotenoid occurring in plants, yellow vegetables such as carrots and sweet potatoes, and dark green leafy vegetables such as spinach. It is the proform of vitamin A and can be converted to vitamin A in the liver. Beta-carotene is an antioxidant but it is not found in the retina. Beta-carotene is rarely toxic in large amounts because of its markedly reduced efficiency of absorption at high doses and relatively limited conversion to vitamin A in the intestine, liver, and other organs.

Consumption of large amounts of beta-carotene may turn the skin a slightly yellow-orange color.[7]

Previous research has found various interactions between the carotenoids including competition during absorption and during postabsorptive metabolism. These interactions might be both beneficial where uptake of other compounds is facilitated, or adverse where absorption and uptake of other compounds is inhibited. In several studies subjects were fed mixtures of lutein and beta-carotene. When lutein was the predominant carotenoid, beta-carotene absorption was inhibited.[5] In another study beta-carotene supplementation antagonized lutein absorption.[5] Few foods that contain relatively high concentrations of lutein contain little or no beta-carotene so there may be an optimal proportion of these carotenoids to give adequate intake of both.

In addition to lutein and zeaxanthin, several other antioxidants and antioxidant enzymes may play a role in protecting the retina against free radical damage. Vitamin C is a powerful antioxidant and also helps to recycle vitamin E. It is found inside cells and in extracellular fluids including those in the retina. It attacks free radicals in biologic fluids and is required for tissue growth and repair, adrenal gland function, and healthy gums.[8] Vitamin C is a water soluble vitamin found in green and red peppers, collard greens, broccoli, spinach, tomatoes, potatoes, strawberries, oranges, and other citrus fruits.

Vitamin E prevents oxidation of lipids and protects cell membranes from destruction by free radicals. Vitamin E is found in the cell membranes of retinal tissues. It improves circulation and is necessary for tissue repair, as well as promoting normal blood clotting and healing.[8] Vitamin E is a fat soluble vitamin found in vegetable oils, wheat germ, nuts, meat, and green leafy vegetables.

Zinc is a required constituent of the antioxidant enzyme, superoxide dismutase (SOD), which converts superoxide radicals to hydrogen peroxide and water. This enzyme is found in retinal tissue. As well, it is needed for proper maintenance of vitamin E levels in the blood and aids in the absorption of vitamin A. Zinc is required for protein synthesis and collagen formation. It promotes a healthy immune system, wound healing, and is vital for bone formation.[8] Zinc is a trace element found in meat, liver, eggs, seafood, yeast, and legumes.

Vitamin A, although not an antioxidant, is a fat soluble vitamin essential for vision in addition to growth, cellular differentiation and proliferation, reproduction, and the integrity of the immune system.[7] Retinoids including retinol, retinaldehyde, and retinoic acid are naturally occurring compounds with vitamin A activity. A dietary plant source of vitamin A is beta-carotene. Additional sources are retinyl esters from animal sources. Excessive intake of vitamin A causes toxicity including headache, dryness of mucous membranes, desquamation, bone abnormalities, and liver damage.

Iron is a trace element found in meat, eggs, green leafy vegetables, and cereals.[7] Iron is involved in the production of hemoglobin and myoglobin, and the oxygenation of red blood cells. Iron is stored in the body and excessive intake can cause excessive iron in the tissues and organs leading to the production of free radicals. This increases the need for vitamin E as an antioxidant. Vitamin C can increase iron absorption by as much as 30% while excessive amounts of zinc and vitamin E interfere with iron absorption.[8]

Because of the gender differences in the macular pigment density and rate of ARMD, this study examined the dietary patterns of male and female optometry students. A recently updated food frequency questionnaire[9] was used to determine the dietary intake of lutein, beta-carotene, fat, iron, zinc, vitamin A, vitamin C, and vitamin E.

Methods

Forty-nine nonsmoking subjects, 24 women (ages 21-34) and 25 men (ages 22-29) were selected for this study. Subjects reported to be in good general health with no malabsorption conditions such as gall bladder disease or intestinal disease.

Dietary information was gathered from each subject using the Health Habits and History Questionnaire.[9] This questionnaire contains over 100 questions regarding specific food items. Subjects indicate both the frequency which the item is consumed and the serving size. The frequency a given item is ingested is indicated by the number of servings per day, week, month or year. Serving size is determined using a visual aid which shows serving sizes of ¼, ½, 1, and 2 cups of food. Supplement use is also assessed. This questionnaire was recently updated to contain items which directly assess lutein intake. Subjects completed the questionnaire in the presence of the experimenter.

Descriptive and inferential statistics were used to examine the data. The mean intake of lutein, beta-carotene, fat, iron, zinc, vitamin A, vitamin C, and vitamin E was found for males and females. The difference in dietary intake between males and females was calculated with values adjusted for differences in caloric intake. The mean intake of these items was compared to the Recommended Dietary Allowances (RDA).[7] Finally, Pearson product moment correlation matrices compared intake of beta-carotene, lutein, vitamin E, and iron to total fat, as well as total fat intake to caloric intake for males and females.

Results

Descriptive statistics for dietary measures for the male and female subjects are given in Table 1. Significant gender differences were found for intake of vitamin C, vitamin E, iron, and zinc with men consuming more than women ($p<0.05$). Men also had a significantly higher intake of fat and calories than females. When these measures were adjusted for caloric intake, a significant gender difference was found for intake of lutein with women consuming significantly more than men ($p<0.05$).

Table 1. Descriptive statistics for the diet measures

	Sample size (n)		Mean (+/-SD)		
	Males	Females	Males	Females	P values
Raw values					
Vit A (RE)	25	24	1590.97 (694.99)	1222.74 (643.53)	P<0.06
Vit C (mg)	25	24	173.76 (81.62)	110.28 (68.24)	P<0.0049[*]
Vit E (α-TE)	25	24	12.32 (4.38)	8.38 (3.16)	P<0.0007[*]
Fe (mg)	25	24	20.76 (5.86)	15.45 (6.41)	P<0.0041[*]
Zn (mg)	25	24	15.30 (4.60)	9.60 (3.04)	P<0.000007[*]
B-carotene (υg)	25	24	3716.36 (2267.61)	2900.00 (2413.03)	P<0.23
Lutein (υg)	25	24	986.80 (514.20)	1294.80 (1312.35)	P<0.29
Calories	25	24	2568.50 (685.49)	1776.52 (625.80)	P<0.00011[*]
Total fat (g)	25	24	101.30 (40.80)	65.70 (26.84)	P<0.0008[*]
% Kcal from fat	25	24	34.60 (6.07)	33.00 (5.24)	P<0.31
Adjusted dietary values					
Vit A/Kcal	25	24	0.63 (0.24)	0.70 (0.33)	P<0.37
Vit C/Kcal	25	24	0.068 (0.03)	0.063 (0.04)	P<0.59
Vit E/Kcal	25	24	0.0048 (0.0012)	0.0047 (0.0011)	P<0.89
Fe/Kcal	25	24	0.0084 (0.0027)	0.0087 (0.0022)	P<0.65
Zn/Kcal	25	24	0.0061 (0.0017)	0.0055 (0.0012)	P<0.20
B-car/Kcal	25	24	1.44 (0.72)	1.64 (1.34)	P<0.53
Lutein/Kcal	25	24	0.40 (0.21)	0.72 (0.70)	P<0.04[*]

[*]Significantly different

Tables 2 and 3 give the correlational analysis for beta-carotene, lutein, vitamin E, iron, total fat, and Calories. For males, there is a strong positive correlation between vitamin E and total fat (r=0.86), and total fat and Calories (r=0.91). For females, a strong positive correlation exists between total fat and Calories (r=0.94), with a weaker positive correlation between vitamin E and total fat (r=0.71), and iron and total fat (r=0.67).

Table 2. Pearson product moment correlation matrices on raw values for males

Males (raw values)

	Total fat	Kcal
B-carotene	0.44	
Lutein	0.11	
Vit E	0.86	
Fe	0.37	
Total fat	1.0	0.91

Table 3. Pearson product moment correlation matrices on raw values for females

Females (raw values)

	Total fat	Kcal
B-carotene	0.11	
Lutein	0.06	
Vit E	0.71	
Fe	0.67	
Total fat	1.0	0.94

Table 4 gives the average intake of selected vitamins, minerals and antioxidants for males and females compared to the RDA. Males exceeded the RDA for all selected items. Females exceeded the RDA for all items except zinc where the RDA is 12 mg and the average consumption was 9.6 mg.

Table 4. Recommended Dietary Allowances[6] of vitamins, minerals and antioxidants

	RDA males	RDA females	Ave. males	Ave. females
Vit A (RE)	1000	800	1590.97	1222.74
Vit C (mg)	60	60	173.8	110.3
Vit E (α-TE)	10	8	12.32	8.38
Fe (mg)	10	15	20.76	15.45
Zn (mg)	15	12	15.30	9.6*
B-carotene (υg)	NA	NA	3716.36	2900
Lutein (υg)	NA	NA	986.8	1294.8

*Does not meet the RDA

Discussion

For age-related macular degeneration to develop, it is theorized that short wavelength light causes the production of free radicals in the outer segment of photoreceptors. These free radicals are either toxic themselves or cause the production of toxic substances that are shed into pigmented epithelial cells during normal sloughing of receptor outer segment components. The toxic products accumulate and are excreted as drusen. Drusen accumulate between pigmented epithelial cells and the choriocapillaris and block the exchange of metabolic materials. The pigmented epithelial cells no longer function and the receptors die.[2]

Antioxidant compounds and enzymes found in the retina can protect these tissues from free radical damage. The carotenoids lutein and zeaxanthin, vitamin C, vitamin E, and zinc quench free radicals without themselves becoming toxic. These vitamins and minerals are not produced in the body and therefore must be obtained from the diet.

In this study females consumed the same amount of lutein as males. However, when the amount of lutein was adjusted for caloric intake, females consumed a higher amount of lutein. Females also consumed significantly less dietary fat which may limit the amount of lutein absorbed from the diet and subsequently deposited in the retina. Similar to our results, previous researchers found no gender differences in dietary intakes of lutein and zeaxanthin.[3] In these same subjects females had higher macular pigment densities than males which could not be explained by differences in the dietary intake of lutein or zeaxanthin. The researchers speculated that there must be a gender difference in the way that carotenoids are metabolized by the retina.[3] These researchers also found a negative relationship between dietary fat and iron intake and plasma lutein and zeaxanthin concentrations. This suggested that although a sufficient amount of fat may be necessary for absorption of lipid soluble carotenoids, high regular intake of fat and iron may cause a decrease in plasma concentration of lutein and zeaxanthin.[3]

The RDA for vitamin C for both males and females is 60 mg.[7] In this study, the RDA was easily exceeded by both the male and female subjects where the mean intake was 173.8 mg and 110.3 mg respectively. There is controversy about the RDA for vitamin C with some suggesting that the level is too low for optimal health.[7] Research shows that many individuals habitually ingest 1 g or more without developing toxic manifestations.[7]

The RDA for vitamin E for males is 10 mg and 8 mg for females.[6] Both males and females in this study met the RDA for vitamin E. Vitamin E is relatively nontoxic when taken by mouth. Most adults appear to tolerate oral doses of 100 to 800 mg/day without signs of toxicity. However, there is lack of evidence of any definitive benefits from vitamin E supplements for normal individuals.[7]

The RDA for zinc is 15 mg for males and 12 mg for females because of their lower body weight.[7] The mean intake for females in this study failed to meet the RDA. This is likely explained by the number of servings of meat indicated by the subjects; the mean for males was 2.55 and for females was 1.65. Chronic ingestion of zinc supplements exceeding 15 mg/day is not recommended; studies have found that supplementation with amounts 20 times the RDA for 6 weeks resulted in impairment of various immune responses.[7]

The RDA for vitamin A is 1000 RE for males and 800 RE for females based on their lower body weight.[7] In this study, the mean intake for both male and female subjects exceeded the RDA (1590.97 RE and 1222.74 RE respectively). Toxicity occurs when daily intake is maintained at more than 10 times the RDA. This dose usually cannot be obtained from foods, except by the sustained ingestion of large amounts of liver or fish liver oils which are particularly rich in vitamin A.[7] The RDA for beta-carotene has not been established. In this study, there was not a statistically significant difference in the mean intake of beta-carotene between males and females.

The RDA for iron for males is 10 mg and 15 mg for females because of iron loss from the menstrual cycle.[7] The mean intake for males in this study was twice the RDA while the mean intake for females barely met the RDA. This is also likely explained by the reduced meat intake indicated by the female subjects. Deleterious effects of daily intakes between 25 and 75 mg are unlikely in healthy adults.[7]

This study examined the dietary patterns of 49 subjects using a food frequency questionnaire. Such questionnaires have been found to be reproducible and valid for use in eye-disease case-control studies. Previous research, using a food frequency questionnaire much like the one used in this study, found reasonable reproducibility when the same food frequency questionnaire was re-administered 12-18 months later. The results of our dietary survey were found to be comparable to results from studies of other dietary questionnaires.[10]

Assuming that the results of this study with young adults can be extrapolated to an older population for which ARMD is a more significant risk, and if lutein actually has a retinal-protective effect, females should be encouraged to raise their lutein levels. They could do this by increasing dietary fat intakes to facilitate absorption of lutein, but this would cause other problems. They could also increase their consumption of high lutein foods, or they could take supplements rich in lutein. Until studies in which the role of lutein in protecting the retina is better defined, encouraging patients to maintain high lutein levels seems desirable.

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